The Reclamation of Lands Stripped for Brown-Coal

By Dr. Wilhelm Knabe

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Doctor Knabe

A translation and condensation

By Dr. M. Paul Koller, Forest Engineer

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Consulting Forester, Ohio Power Company

INTRODUCTION

In the extensive lignite (brown-coal) fields of Mideastern Germany strip-mining began in the early 1800's. From a very modest beginning this coal has grown to be the major source of energy today. In order to produce enough coal to meet present demands, land is being stripped at the rate of about 5,000 acres annually. The output of the stripmines amounted to 98% of the total brown coal production of about 212 million tons in 1957. In the same year the production of bituminous coal by underground mining reached only 2.8 million tons in Mideastern Germany. In addition to the areas already mined about 700,000 to 1,300,000 acres still remain as coal reserves. The sum of mined and reserve coal fields, when considered collectively would constitute from 2.8 to 5.2 percent of the total area of Mideastern Germany. However, as a result of the regional concentration of the coal fields over many contiguous square miles, some districts will result in over 25% of the land being ultimately stripped. Because of the immensity of the stripping operations, and the desire to insure an economic future for the mining districts, the author felt a strong desire to launch the present study in spite of the many difficulties to be encountered in such an undertaking.

1/ Knabe, Wilhelm, Zur Wiederurbarmachung in Braunkohlenbergbau. Deutscher Verlag der Wissenschaften. Berlin 1959. 154 pp. illus.

2/ Dr. Knabe is a German soil scientist at the Federal Research Experiment Station for Forestry and Forest Products, Reinbek near Hamburg, Germany.

He was appointed as a Post Doctoral Fellow at the OAES to consult in stripmine reclamation research during the summer of 1962.

In addition to the lignite fields of Mideastern Germany, some 500,000 to 700,000 acres occur in Western Germany, several hundred thousand in each of Czechoslovakia and Hungary. In Great Britain, noted for its deep mining, approximately 70,000 acres have been stripped for coal by 1952 as well as a similar area stripped for metallic ores. In the United States about 450,000 acres had been mined by surface methods by 1950; the United States coal being principally bituminous (black coal). Similarly, in the Soviet Union and China, large areas have been stripped for coal, ores and other minerals.

A previously unequalled level of industrialization together with a high standard of living have been the result of the removal of coal, ores and other raw materials by surface mining. However, it is the general desire of the public, land owners and conservationists to return the disturbed land to economic production, eliminate all evidence of strip-mining and re-establish the continuity of the vegetative cover over the landscape.

The present study promises to contribute a very essential link in the achievement of the above goals since, for the first time, the entire problem of strip-mine reclamation has been treated. It should be emphasized that the present study was made with special reference to the brown coal regions of Mideastern Germany.

THE STUDY - PART ONE

This study is comprised of two parts, the first of which deals with the general problems of strip-mining, its consequences and reclamation. The second part deals with certain experiments performed as a result of conclusions made in the first section.

Strip-mining changes the entire appearance of the landscape. A detailed treatment of the consequences and changes caused by strip-mining are presented. Both positive and negative factors are included in the discussion. Such factors as the contribution to large industrialization, changes in the extent of land suitable for cultivation and human habitation, production of a new type of man-made ground material of loose structure, establishment of extensive barren areas, changes of topography and water economy, especially the acid mine drainage from stripped areas, increased sources of dust and smoke, changes in climate, human settlement and traffic systems are considered in some detail. These changes call for an adjustment in order to allow a continuation of cultivation and habitation of these lands. We call these adjustments "reclamation". Proper reclamation presupposes an adequate knowledge of the agricultural value of all material (overburden) brought to the surface during the removal of coal.

On the other hand, the mining industry was concerned primarily with a knowledge of the quality and quantity of coal and its relation to the proportion of overburden materials. Similarly, the mining geologist had little agricultural concern and was primarily interested in composition, age, origin, and history of the materials overlying the coal deposits. But the agriculturist and forester see in this overburden the raw material for new lands, suitable for agriculture. For this reason they have to look for the agricultural value of these materials. To do this a thorough knowledge of the chemical and physical properties of the overburden together with a knowledge of climatological and topographic factors are of prime importance.

For the above purpose, individual overburden layers have, for some time, been classified as follows:

A. Layers suitable for general agriculture.

B. Layers suited only for forest crops.

C. Layers unsuited to any agriculture due to physical or chemical reasons.

However, there are layers which might be used to ameliorate others or are marginal between two of the above classes. As a result, in 1952 the author introduced another scale of classification with 5 classes. This was done to separate, during mining, certain layers in need of a different future management. They may be summarized as follows:

I. Very good - well suited to general agriculture.

II. Good - generally suited to general agriculture.

III. Medium - suited, principally, to forest crops.

IV. Bad - suited to revegetation, but without economic yields.

V. Very bad - unsuited to plant establishment because of toxic chemical compounds.

This classification proved to be quite practical in the enforcement of the 1952 reclamation law in Mideastern Germany. This law stated that only the first three classes or a combination thereof could be placed upon the surface of the newly established ground. This requirement could be fulfilled if and when experts investigated the individual layers and classified them and the mining industry cooperated by following their recommendations.

It is maintained, by the author, that in view of the large areas involved, the increase in population and the general increase in technical advancements, strip-mine reclamation efforts arrived at a recent turning point and may be summarized by the following axiomatic statements.

1. That mining and reclamation must be viewed as one entity of complex activity in which the mining industry serves a nation both by producing coal and by properly reclaiming the land for use by many generations to come.

By failing to see this entity a certain stagnation in the development of reclamation has resulted during the present time. The success of reclamation is not determined by the results of the pioneer vegetation, but by the success of the crops to come later. At this time, all mined lands will be integrated into the total area of the cultivated landscape. In any given area there are four main factors which determine the quality and quantity of the future productivity of strip-mined lands under successful integration.

(a) The properties of the overburden layers.

(b) The methods of mining with regard to coal recovery and resulting land form.

(c) The methods of agricultural re-establishment using herbs and trees.

(d) The intensity of the subsequent agricultural practices.

Of these four factors, only the first cannot be influenced by man. The others depend firmly on the will and understanding of a nation and on its social condition as well as its technical and economic possibilities. The nation itself is responsible for how its strip-mined lands look and yield.

2. The second axiom is that our strip-mining has passed the stage where the performance of mining and reclamation can be accomplished without advance planning of both on a scientific basis.

In order to succeed in these operations the knowledge and cooperation of the miner, geologist, soil scientist, chemist, geotechnician, conservationist, agronomist, forester and landscape architect must be used. The time of haphazard methods of revegetating spoil banks is past. Future revegetational methods require planning in which the characteristics of the spoils banks are known in advance by analytical techniques and for which the desired plant cover is selected to best fit the analytical findings. When mining is being planned for a new coal field, test holes are drilled to determine the quality, quantity and faults of the coal. At the same time overburden data such as consistancy, rocks, quicksand, water, coal-overburden ratio, mining economy, machinery to be used, etc. are recorded. From these same findings it should be possible to determine how and where to establish the new land surface arising from the overburden. This should be done so that its shape and slopes would correspon to the requirements of the material itself as well as that of the environment. Also, proper planning should include some provision for the placement of only the most productive materials at the surface.

In order to determine the agricultural value of the overburden, all strata must be analyzed with regard to their chemical and physical properties. This must be done at the same time as the exploratory drilling and with the test core material. On-the-spot investigations as well as laboratory and pot culture tests should be conducted in order to establish their agricultural value. The goal of all these investigations is to establish a feasible mining procedure which will ensure the placement of the better strata on the surface. This type of mining may be called: "mining with productive soil management". When soil materials are placed on the surface of the better rock strata the term, "mining with top-soil management", may be used.

PART TWO

The second part deals with a series of experiments which were the result of ideas and conceptions mentioned in the first part.

The strip-mining law of Mideastern Germany, issued in December 1951, prescribed "Productive soil management" in several mining districts. Following the personal recommendations of the author, test core drillings on most of the areas were accompanied by laboratory and pot culture tests and their best use established in many test series. Laboratory and greenhouse analyses included all different strata where more than one occurred. In all cases suitable statistical methods were employed. In addition, trials of soil amendments such as N, P, K and lime were tried. Pot culture trials at the critical margin of toxicity included the use of wild mustard (*Sinapis alba* L.) and yellow bitter lupine (*Lupinus luteus* L.) since these species appeared to be the most useful to find out grades of soil toxicity and those of soil ameliorating effects.

Chemical and physical investigations were very elaborate and included all known soil testing methods recommended by United States soil scientists for strip-mine materials. The tests themselves were tested as to their applicability and included the following:

1. Texture - Dry sifting and washing (Kopecky) sedimentation (Köhn).
2. Mineral composition.

3. Water content of air dry material. (Thun-Herrmann.)

4. Loss on ignition at 500-600° C. (Thun-Herrmann).

5. Maximum water holding cap. (Mitscherlich.)

6. pH - in H_2O and in Normal KCl colorimetrically with indicator paper, electrometricall with Platinum-Quinhydrone, or better with glass electrodes.

7. Titratable free acidity, after 30 minutes boiling in distilled water.

8. Exchange acidity.

9. Exchange lime in Normal KCl.

10. Hydrolytic acidity in Normal Ca-acetate. (Kappen & Thun-Herrmann).

11. T-value (Cation exchange capacity) (Rhode's unpublished procedure).

12. T-S value (Exchangeable Hydrogen). (Rhode's unpublished procedure).

13. S value = T value minus T-S value. (Exchangeable cations).

14. Electrometric neutralization, 3-day equilibrium with lime. (Jensen).

15. K_2O, P_2O, SO_3 contents, extracted with hot concentrated HCl (Thun-Herrmann).

16. Soluble Ca, Mg, SO_4 in cold HCl extract.

17. Total Nitrogen (Kjeldahl, Method of Foerster.)

18. Pyrite sulfur after the removal of sulfate sulfur.

19. Total sulfur (Eschka).

20. Detection of Fe +++ ions with 10% KCNS solution (Kohnke).

21. Qualitative test for sulfides with sodium azide in iodine solution (Kohnke).

22. Quantitative test for sulfides and pyrites, a quick method with zinc, HCl, and lead acetate paper (Deitschman and Neckers).

The primary purpose of these investigations was to establish the potential agricultural value of each layer of the overburden, namely:

(a) Texture and the correlated water holding capacity and exchange capacity.

(b) The acidity status, including its sources (Pyrite, Marcasite).

(c) The nutrient status (Mineral and chemical).

(d) The quality and quantity of organic substances.

The above investigations meant that real pioneering work had to be done. It was soon established that many procedures conventionally used for surface soils could not be applied in the same way for the deeper strata. This proved to be especially true for pH values and in the determination of lime requirement. The degree of acidity (pH) of naturally developed soils may indicate if surplus base or hydrogen ions are present. Similarly, the T and T - S values may permit the quantitative determination of base saturation. Because of the very changeable nature of the fresh spoil material, any on-the-spot determinations give only a fleeting glimpse of the changing conditions. These rapid changes are due to moisture, temperature, exposure, etc. and because of this, a more complicated method had to be substituted. The "Base-Acid Balance" met these requirements and allowed a better agricultural evaluation to be made. A simplified method of this "Base-Acid Balance" would consist in a comparison of the amounts of sulfides and calcareous materials ($Ca\ CO_3$ - $MgCO_3$).

The analytical results were tabulated, charted and graphed in order that mining administrators could interpret them for their purposes. Thus the drill cores were represented in a vertical column to scale with texture differentiation in color or graphically distinguishable. Acidity (total sulfur, free acid, exchange lime) values were graphed horizontally and the agricultural value of each layer was expressed by grades in a vertical manner. In this way, the author furnished several mining districts with such complete overburden analysis that they were able to put "mining with productive soil management" into field operation.

A sample recommendation for the future opening of a coal field is given with the establishment of factual proceedings also listed. In this procedure the author draws a net of squares with grids spaced 600-1000 feet apart. At each grid intersection a test hole would be drilled and samples taken from all layers which differ from one another by way of texture, color or mineralogy. Three different investigational stages will be applied to the test samples.

I. Tests by the drilling foreman who must be familiar with the test methods.

   (a) For the presence of $CaCO_3$ with 10% HCl.

   (b) For the presence of Fe +++ ions using potassium thiocyanate both before and after H_2O_2 treatment.

   (c) For sulfides using sodium azide (NaN_3) in iodine solution.

II. Laboratory tests made on samples at grid corners 1200-2000 feet apart in order to check results of the drilling foreman as well as further characterize the spoils.

   (a) Water-holding capacity.

   (b) Lime requirement.

   (c) Sulfur - total and pyrite.

   (d) Free acidity.

   (e) Carbonates (Ca, Mg, etc.) with acids.

   (f) T value, T-S value.

   (g) Texture.

   (h) Phosphate.

   (i) Potash.

All data needed for the base-acid balance are expressed in milli-equivalents per 100 grams of material.

III. Laboratory and greenhouse tests made on samples at grid corners 2500-5000 feet apart.

The final results of all tests are to be tabulated and charted in order to determine the agricultural value of the total overburden. The latter tests (III) will give reliable results for comparative purposes. The resulting recommendations are accompanied by tables and charts of the test data.

Special Problems

In this section reference is made to the reclamation of old mine banks, which for several decades have not supported vegetation.

The following reasons for the hostile conditions were found.

1. Extremely acid reaction (pH 2.0 - 3.5) resulting from the oxidation of sulphides.
2. Poor physical properties (water-repellent, poor infiltration) resulted in excessive runoff and prohibited normal percolation and leaching.
3. Lack of mineral nutrients.

Three successful approaches were made on areas of several acres each. In each case, good revegetation was the result.

(a) With Ca O and NPK fertilization in Boehlen.

(b) With the incorporation of a 2 inch layer of brown-coal ash (from power plants) together with NPK fertilization in Schwarzkollm.

(c) With the incorporation of 0.5 - 2 inches of coal ash together with CaO.

In all cases a heavy disking (15 - 20 inches deep) was used and resulted in grass and tree cover even though these areas had been previously given up as being not suitable for revegetation.

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The final chapter of this work ends with the sober simple conclusion that the rebuilding of the minable area has to be planned before the depletion of the coal has been begun and it is no less a paramount duty of all involved. With common good will and cooperation it can and must be accomplished.

A reference list of 155 publications accompanies the text to furnish further information by other authors in the subject.

The brown-coal strip mine lands both in their way of mining, in the quality and origin of the coal of the Miocene, and the nature of the overburden are very different from our coals of the Pennsylvanian Epoch. The problems of re-establishing the surface, after mining, however, show very similar features.

This study, because of its international value and especially its method of approaching the problem offers valuable insights to all conservationists. The common goal, of successful strip-mine reclamation, must be approached from a new direction.

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